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PRODUCTIVITY OF NEW YAM ASSESSIONS AS AFFECTED BY MOSAIC VIRUS IN TRANSITION FOREST-SAVANNA ZONE OF CÔTE D'IVOIRE

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ABSTRACT

Yam is being a strategic crop for food security in West Africa. However, there are many constraints that limit its productivity. Among the constraints, we have low quality of seeds and pest pressure. Therefore, there is a need to assess the tolerance of new cultivars released, especially for yam mosaic virus (YMV) wide spreader in yam agro-ecologies. During the cropping seasons of 2000 and 2001, a trial was conducted in augmented design including sixteen varieties of yam in four replications according to a density of 30000 plants per hectare. The checks were the local varieties named Bete bete and Florido. The severity effect of YMV was measured at 2, 4 and 6 months after planting. The results showed a significant effect of YMV on check cultivars and some improved varieties in 2000 and 2001 as well as significant correlation between canopy surface rate and yields. Highest yield (32 t/ha) was obtained in 2000 by the improved variety 98_01176 among eight tolerant cultivars while 14.9 t/ha was recorded for the local cultivar Bete bete. These best varieties could be recommended to farmers to increase their production in a sustainable cropping system.

KEYWORDS: Yield**,** Yam Mosaic Virus, Yam Assession, Canopy Surface Rate, Côte d'Ivoire

INTRODUCTION

Yam (Dioscorea spp) is important for food security in West Africa producing more than 90% of the worldwide production (FAO, 2009). Besides its importance as food source, yam also plays a significant role in the socio-cultural lives of people in some producing regions like the celebrated New Yam Festival in West Africa (Osunde and Orhevba, 2009) and wedding ceremonies in Oceania (O'Sullivan and Ernest, 2008). Cultivated yams belong to the Dioscoreceae and the genus Dioscorea families. There are also species of wild yam growing in Côte d'Ivoire whose tubers are collected for eating in times of food shortage. Yam is a valuable source of carbohydrate to the people of the tropical and subtropical Africa, Central and South America, parts of Asia, the Caribbean and Pacific Islands (Adelusi and Lawanson, 1987). Yam is subject to the depredations of several pests reducing production. The Yam Mosaic Virus (YMV) genus Potyvirus, from the family of family Potyviridaeis is the most important virus infecting both cultivated and wild yams especially *Dioscorea rotundata*, *D. alata, D. cayenensis and D. praehensilis* in the yam-growing areas of the world (Thouvenel and Fauquet, 1979; Porth et al., 1992). The Yam Mosaic Virus is reported in the growing regions of Nigeria, Ghana, Cameroon, Benin, Côte d'Ivoire, Burkina Faso and Togo in West Africa (Porth et al., 1992; Thottappilly, 1992; Brunt et al., 1996). According to International Institute of Tropical Agriculture-IITA (IITA, 1981), YMV causes several symptoms including mottling, leaf

and vein chlorosis, leaf mosaic, leaf distortion and malformation, shoe stringing of leaf as well as plant stunting causing about 40% of yield reduction in *D. rotundata* as the most threatning virus disease. Protection of crops against pathogens may be realized by different means such as chemical and biological controls as well as the use of resistant varieties (Babajide, 2011). Breeding for resistance is usually preferred due to its cost effectiveness and the minimal impact on the environment (Hogenboom, 1993). This preference results from the fact that once resistance to the causal agent of the disease is established it can be transferred from generation to generation. For a higher level of food production, greater income and improved nutritional status of the poor people of sub-Saharan Africa, resistant landraces grown in the region must be identified and hybridized with other genotypes having targeted qualities to bring about high-level resistant offspring with improved and reliable yield.

The overall goal of this study was to recommend some new yam with high yield and resistant to the damages of pests and diseases. The study was specifically initiated to find new yam with high yield and resistant to YMV in the savanna zone.

MATERIEL AND METHODS

Location of the Study

This study was conducted in Bringakro (6° 401'N, 5° 091'W, 150 m alt.) the transition forest-savanna zone in Côte d'Ivoire. It is an equatorial transition climatic zone with an annual bimodal rainfall pattern ranging from 900 to 1300 mm. The annual rainfall of 2000 and 2001 are illustrated in Figure 1. Annual average temperature and hygroscopy were 27°C and 70 % respectively. The vegetation of the site was a long fallow of *Imperata cylindrica*. Parameters of this area have been previously described (Ettien et al., 2013).

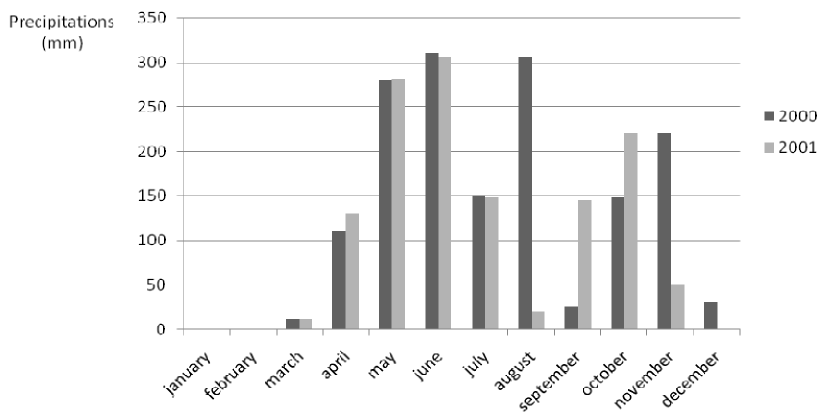

Figure 1: Rainfall during the Experiments in 2000 And 2001

Vegetative Material

Seventeen assessions of *Dioscorea alata* were used in 2000 and 2001. The size of each seed was 70 g whereas the size of the local checks was 280 g planted at 10 000 t/ha. It means one plant per square meter and the same weigh /m2 in comparison with the weighs of improved seeds varieties per square line. The weight of the local variety was four times superior to that of the assessions' because of their bad quality.

Experimental Design

The experimental design used was the augmented design with four replications every year in 2000 and 2001. This experimental design has been described (Nokoe, 1999; Ettien et al. 2013). The planting bed size was 15 m x 10 m.

More simply, the total surface used per subplot was 150 m^2. Each planting bed was a replication and four replications were established. Seeds of *D. alata* were planted in lines at 30000 plants/ha for nine months of vegetation (May-January). A line corresponded to one variety used in each block.

Data Collection

Virus

The virus effect was scored on a scale of 1 to 5 with value in table 1 according to IITA (1996). The viruses are mainly the Yam Mosaic Virus (YMV) and the "shoe string" (SS) or shoelace form. As far as the YMV symptoms are concerned, they are characterized by the depigmentation of the active surface of the adult leaves, the edgings and the surface between the leaf veins. During the advanced stage of the disease, the plant becomes stunted and dwarf. The "shoe string" causes the elongation of the leaf, followed by a narrowing of the leaf surface. Its priority is to attack and cause and ramifications of the stem. The method of measurement of viruses focused on the severity. We observed that each foot ranged on the ridge while counting the number of infected plants.

Then we gave a score ranging between 1 and 5. The observations of the disease began when the plants began full vegetation phase two month after planting. During this phase, the symptoms of the disease are evident. For example, on a ridge with 60 plants, if 3 plants show mosaic symptoms, it means that 3 out of 60 plants are sick, which corresponds to 5%. It is therefore 1 in class 1-25% of the rating scale. It has made 3 measurements.

Table 1: Scale Value Used to Score the Infection of Mosaic

Score	Percentage of Infested Plants	Status of the Plant
1	0	No virus
2	1-25	Low attack
3	26-50	Moderately resistant
4	51-75	Weak resistance
5	>75	No resistance of the plant

Canopy Surface Rate

Coverage rates were also measured on a scale of 1 to 5 as mentioned in table 1. Example: Note 1 shows that the ridge is not covered and the ground is clearly visible, while the score 5 shows that the ridge is completely covered, and the ground is not visible. Between 1 and 5 the others values are intermediate. Cover was scored within 2 months, 4 months and 6 months.

Yield

At the harvest, the tubers of each variety were weighed by line to get the yield after statistical analysis. The fresh weigh of each assessions and locals' were thus scored.

Statistical Analysis

Analysis of variance (ANOVA) factorial type for yield, effect of virus and cover were made using the 8.2 version of the SAS software considering the diseases, cover and yield as the factors studied. The least significant different method (LSD) was used to separate means values.

RESULTS

Yam Mosaic Virus Effects and Varieties Performance

The results showed that YMV effect varied in the field depending on variety. Table 2 shows the comparison of mean value of YMV effect on the assessions and the local cultivar (cv) Bete Bete as well as on cv Florido. The cv Bete Bete was inferior to the variety TDa 95_00226. Local cv Bete Bete was less resistant to YMV than TDa 95_00226. The improved variety was tolerant to YMV. Similar results were obtained with the assessions of TDa 95_00387, 98_01176, 95_00799, 95_00079, 95_00010 compared with Florido 98_01187. There was no significant difference for other comparisons. The mean value of Bete Bete was also lower than that of Florido (Table 2).

Table 2: Comparison of the Average Effect of YMV According to the Yield on Assessions and the cv Bete Bete over Two Year

Comparison of Varieties	Differences Between Yield	Confidence Limit (95%)	Significance at α =0.05
Bete bete - 95_00226	-11.500	-21.095 -1.905	***
Bete bete - 95_00387	-10.850	-16.390 -5.310	***
Bete bete - 95_00799	8.525	-14.065 -2.985	***
Bete bete - 95_0079	-7.800	-13.340 -2.260	***
Bete bete - 98_01174	-7.500	-17.095 2.095	ns
Bete bete - 98_1177	-7.300	-16.895 2.295	ns
Bete bete - 95_00010	-6.425	-11.965 -0.885	***
Bete bete - Florido	-6.100	-10.623 -1.577	***
Bete bete - 98_01187	-5.900	-15.495 -1.577	***
Bete bete - 98_01183	0.200	-9.395 9.795	ns
Bete bete - C123	0.600	-8.995 9.795	ns
Bete bete - 98_01166	1.100	-8.495 10.695	ns
Bete bete - 98_01184	2.000	-7.595 11.595	ns
Bete bete - OA07	2.800	-6.795 10.695	ns
Bete bete - EM10	5.500	-4.095 15.095	ns

******* Highly significant
ns: no significant difference

Table 3 shows the comparison of YMV effect on the assessions and the local Florido over two years. The difference was highly significant between Florido and 98/01176, Bete Bete and EM 10. It meant that Florido is more tolerant to YVM than these varieties. Florido, one of the controls was compared to all the other varieties studied. It has been observed that Florido was higher than the control Bete Bete and improved EM10 with a highly significant difference. All other improved varieties were almost higher than Florido. However, the differences were not significant at the 5% threshold. This demonstrates the performance of Florido and the improved varieties. It showed their good tolerance to YMV. Table 4 shows the comparison of the assession 98_01176 to the other varieties according to YMV effect. It was noted a highly significant difference between 98_01176 and the other varieties tested except the variety 95_00226. Indeed, the difference between 98_01176 and 95_00226 was not significant. This means that these two varieties had the same strength potential to YMV. The Pearson correlation test was performed to highlight the relationship between coverage rate and yield, coverage rate and the effect of YMV, the yield and the effect of YMV. The test showed that the coverage rate was negatively correlated with yield ($r = -0.31651$). It acted in a strong negative correlation (between -1 and -0.5, table 5). The difference was significant ($p = 0.009 < 0.05$). This meant that the performance of the variety was influenced by the coverage. YMV had a negative correlation with yield ($r = -0.11163$) but the difference was not significant at 5%. This also meant that YMV had no negative effect on the yield of yam, showing tolerance of the improved varieties. The Yam Mosaic

Virus positively correlated with the coverage rate, but this correlation had been low (between 0.0 and 0.5). This meant that the coverage rate had not been influenced by YMV.

Table 3: Comparison of the Average Effect of YMV on Assessions and Local Florido over Two Years

Comparison of Varieties	Differences Between Means Compared	Confidence Limit (95%)	Significance at α =0.05
Florido - 98_01176	-11.800	-21.395 -2.205	***
Florido - 95_00226	-5.400	-14.995 4.195	ns
Florido - 95_00387	-4.750	-10.290 0.790	ns
Florido - 95_00799	-2.425	-7.965 3.115	ns
Florido - 95_0079	-1.700	-7.240 3.840	ns
Florido - 98_01174	-1.400	-10.995 8.195	ns
Florido - 98_1177	-1.200	-10.795 8.395	ns
Florido - 95_00010	-0.325	-5.865 5.215	ns
Florido - 98_01187	0.200	-9.395 9.795	ns
Florido - Bete bete	6.100	1.577 10.623	***
Florido - 98_01183	6.300	-3.295 15.895	ns
Florido - C123	6.700	-2.895 16.295	ns
Florido - 98_01166	7.200	-2.395 16.795	ns
Florido - 98_01184	8.100	-1.495 17.695	ns
Florido - OA07	8.900	-0.695 18.495	ns
Florido - EM10	11.600	2.005 21.195	***

******* Highly significant
ns: no significant difference

Table 4: Comparison of the Average Effect of YMV on Assessions and the Two Checks over Two Years

Comparison of Varieties	Differences between Means	Confidence Limit (95%)	Significance at α =0.05
98_1176 - 95_00226	6.400	-6.393 19.193	ns
98_1176 - 95_00010	11.475	1.361 21.589	***
98_1176 - Florido	11.800	2.205 21.395	***
98_1176 - 95_0079	12.900	0.107 25.693	***
98_1176 - 98_01177	13.100	0.307 25.893	***
98_1176 - 98_01187	13.700	0.907 26.493	***
98_1176 - 98_01174	13.700	2.007 27.593	***
98_1176 - 95_00387	15.800	3.007 28.593	***
98_1176 - Betebete	17.900	8.305 27.495	***
98_1176 - 98_01183	18.100	5.307 30.893	***
98_1176 - C123	18.500	5.707 31.293	***
98_1176 - 98_01166	19.000	6.207 31.793	***
98_1176 - 98_01184	19.900	7.107 32.693	***
98_1176 - OA07	20.700	7.907 33.493	***
98_1176 - 98_01183	20.800	8.007 33.593	***
98_1176 - 98_00799	22.400	9.607 35.193	***
98_1176 - EM10	23.400	10.607 36.193	***

******* Highly significant
ns: no significant difference

Table 5: Pearson Correlation Test to Show the Relation between the Parameters

Parameters	Yield	Coverage	Yam Mosaic Virus
Yield	1.00000	-0.31651	-0.11163
P value of yield at 0.05		0.009	0.372
Coverage	-0.31651	1.00000	0.10141
P value of coverage rate of yield at 0.05	0.009		0.417
Yam Mosaic Virus	-0.11163	0.10141	1.00000
P value of YMV	0.372	0.417	

Table 6 translated the general trends of the average rate over the two years. Indeed, the coverage rate in 2000 and 2001 were identical. There was no significant difference between the two years (p = 0.74) at 5%. This was true for the effect of YMV. As for yield, it obtained a better yield in 2000, showing a significant difference (P <0.004) at the 0.05 level.

Table 6: Annual assessment of Factors Observed over the Two Years

	Coverage	Yield (t/ha)	YMV
Year 2000	4.31a	21.47a	1.08a
Year 2001	4.60a	17.49b	1.11a
CV (%)	13.47	27.44	31.25
Probabilty > F	0.05	0.004	0.74
General mean	4.34	19.78	1.09

Means with the same letters were not significant different at α=0.05;
LSD (YMV) = 0.1697

The yields had varied from 9 to 32 t/ha in 2000 while in 2001 they had varied from 9 to 25 t/ha. The yield went down in 2001 for each variety (figure 2). In general, yields of the yams in 2000 were higher than yields in 2001 (figure 3). The difference was significant between the two years. The attack of virus was very low because the values ranged between 1 to 25 according to the scale.

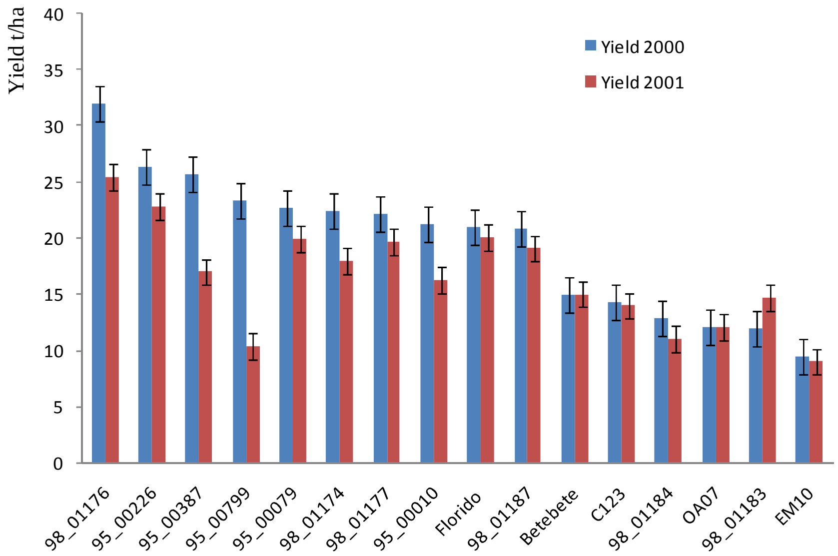

Figure 2: Yield of Assessions in 2000 and 2001

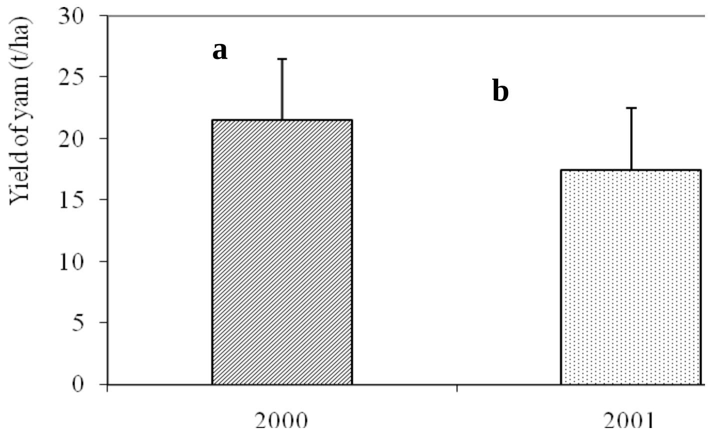

Figure 3: Comparison of General Means of Yam Yields In 2000 and 2001 Means with the Same Letters were not Significant Different at α=0.05

Effects of Coverage Rate and YMV on the Yield of Evaluated Assessions

The coverage rate was negatively correlated to the yield of the yams. Indeed, the coverage rate negatively influenced the process of developing the yield of yams or did not play a significant role in the synthesis of carbohydrates.

Rainfall during the Study

It was noted that in August, the height of rainfall was very important unlike that of 2001 (figure 1). In fact, the month of August in this region marks the peak of the dry season which starts in July and comes to an end in September. In 2000, a regular distribution of rain according to the seasons was noted.

DISCUSSIONS

Yam Mosaic Virus Effects and Varieties Performance

Although YMV has been reported to be a serious threat for yam production in West Africa, it didn't as much affect the yield during the current study carried out in the savanna area under ferralsol poor in organic matter. The scores recorded were low and shoes laces stages as shoe string did not occurred within the period of 6 months. Therefore, the yields were higher than the national average for almost all the yam assessions except for 9 which were ranging below the yield of the control-Florido. Nine varieties could be classified as elite varieties due to their yields and their resistance to YMV. Safety seed can contribute to this performance (Amusa et al., 2003; Babajide et al., 2011; Eni et al., 2013). The resistance of the assessions indicated that they could be considered as promising varieties to fight against poverty in rural area.

Effects of Coverage Rate and YMV on the Yield of Evaluated Assessions

The action of coverage rate means that getting a high rate does not bode high performance but it depends on many other factors such as solar radiation and the source-sink relationship as demonstrated in the same area (Hgaza et al., 2010). It was also noted that the YMV also had a negatively correlation on the yield of the varieties. This means that the Yam Mosaic Virus has a negative impact on the performance of yam. These results correspond to those obtained in Nigeria during inoculation experiments to verify the resistance of varieties to YMV (Odu et al., 2004). Improved varieties tested in this study showed their tolerance to this pathology unlike control Bete Bete. This tolerance of the assessions to YMV is an asset for farmers for sustainable yam cropping on ferralsols in West Africa. Local Florido used as a control showed its

performance compared to some assessions. The variety TDa 98_01176 (or 98_01176) potential showed more resistance to the virus disease than any other improved varieties. In reality, Florido is an improved variety of Puerto Rico which has been introduced in 1983 in Côte d'Ivoire. Here is why the potential of this variety is very high. Furthermore, its yield had been higher than some assessions. Indeed, improved varieties tested in this study were selected for their tolerance to YMV, for good coverage and high yield. The study showed that the coverage rate had been almost the same in the two years. There was no significant difference between the two years. The lack of YMV effect and its severe form was the consequence of the important coverage rates observed and high yields recorded (Eni et al;, 2013). This was also due to the resistance of yam varieties. As for performance, it was obtained a large variation which resulted in a highly significant difference from one year to another. In 2000, the average yield of all varieties was higher than the average yield of varieties in 2001. The improved variety TDa 98_01176 obtained the highest yields in 2000 and 2001 followed by improved 95_00226 reflecting their relatively high performance faced to YMV. These elite varieties can be integrated into breeding programs and improve the productivity of yam on ferralsols in West African.

Rainfall during the Two Years of the Study

The irregular rains from year to year could have disturbed the physiological cycles of yams in 2001, which could have resulted in water stress. Indeed, it has been shown that nitrogen needs in yams nutrition are important from the tuber initiation phase which starts the 8th week after planting (Nwoke et al., 1984). At this stage, nutrients must be available in the soil solution, which requires the presence of water. This phase of tuber initiation continues at the 20th week that is to say five months after planting. During this significant stage, it is important that soil includes major nutrients which must be available for yam. Periodical drought observed in 2001 could have had an effect of the YMV severity on yields. However, there was no link shown between time and the growth of yams.

CONCLUSIONS

This study showed the advantages of improved *Dioscorea alata* overlooked of the manifestations of YMV without external input varieties. It was noted that more than 8 improved yam varieties were superior to traditional controls. They presented a high resistance to YMV and its severe form. Indeed, YMV is recognized as a major constraint for yam in West Africa, specifically for limiting their performance. These varieties can thus be considered as elite varieties, especially TDa 98_01176 and TDa 95_00226 which outperformed all the assessions tested. Elite varieties obtained in this study should be recommended to improve the selection and production of quality seeds from one planting season to another because the issue of quality seed is also a concern in rural areas.

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